PRV

PATENT- OCH REGISTRERINGSVERKET
Patentavdelningen

Intyg
Certificate

Härmed intygas att bifogade kopior överensstämmer med de handlingar som ursprungligen ingivits till Patent- och registreringsverket i nedannämnda ansökan.

This is to certify that the annexed is a true copy of the documents as originally filed with the Patent- and Registration Office in connection with the following patent application.

(71) *Sökande* *Maquet Critical Care AB, Solna SE*
Applicant (s)

(21) *Patentansökningsnummer* *0300847-1*
Patent application number

(86) *Ingivningsdatum* *2003-03-26*
Date of filing

Stockholm, 2004-01-20

För Patent- och registreringsverket
For the Patent- and Registration Office

Hjördis Segerlund

Avgift
Fee *170:-*

PATENT- OCH REGISTRERINGSVERKET
SWEDEN

Postadress/Adress
Box 5055
S-102 42 STOCKHOLM

Telefon/Phone
+46 8 782 25 00
Vx 08-782 25 00

Telex
17978
PATOREG S

Telefax
+46 8 666 02 86
08-666 02 86

Description

Apparatus for and Method of Calibrating a Resistance Thermometer and a Gas Analyser Employing the Same.

The present invention relates to an apparatus for and a method of calibrating a resistance thermometer, particularly a resistance thermometer comprising a thermally sensitive resistance element in operable connection with a bridge measurement circuit used to measure gas temperatures in a gas composition analyser.

Resistance thermometers, for example ones employing a thin platinum wire as a thermally sensitive resistance element, are well known in the art. The electrical bridge circuit to which such an element is provided in operable connection is most usually configured so that a thermally induced electrical resistance change of the resistance element produces a linearly dependent change in an electrical parameter of the circuit, such as voltage or current. This parameter is then supplied as a measure of the temperature sensed by the resistance element.

In order to ensure that the resistance thermometer provides an accurate indication of a temperature to be measured it should be calibrated at least once, preferably at a plurality of occasions, during its operation. The typical calibration procedure which is followed is a multi-point, normally two point, calibration where the output from the bridge circuit is recorded at multiple of known reference temperatures. Often a calibrated reference thermometer is located in thermal contact with a system, the temperature of which is to be monitored by the resistance thermometer, and used to provide the reference temperatures against which the resistance thermometer is calibrated.

Such a calibration procedure, even using only two points, is not trivial since the system, the resistance element and the reference thermometer must be allowed to come into thermal equilibrium before each calibration point is recorded. This results in a relatively lengthy calibration procedure.

It is an aim of the present invention to provide an apparatus for and a method of calibrating a resistance thermometer for use in monitoring a gas temperature using a more rapid two point calibration procedure.

According to a first aspect of the present invention there is provided a calibration apparatus as described in and characterised by the present Claim 1. By employing a combination of a direct reference temperature measurement for generating the first reference temperature value as a first temperature calibration point and an acoustic velocity related measurement for generating the second reference temperature value as a second temperature calibration point then the system needs only to be in equilibrium when establishing the first temperature calibration point. Thus the length of the calibration procedure is reduced.

Preferably, an acoustic velocity related measurement is also made within the gas for which the first reference temperature value is generated and employed in combination with the other acoustic velocity related measurement in the generation of the second reference temperature value. This permits an unknown acoustic path length and/or a gas of unknown composition to be used in the calibration procedure since the unknown value or the relationship between the unknown values can be determined from the acoustic velocity related measurement within the gas for which the first reference temperature value is generated.

Usefully, a gas composition analyser employing a resistance thermometer and an acoustic meter for the determination of information relating to the composition of a gas and including a calibration apparatus according to the first aspect of the present invention may be provided. Advantages that are associated with the apparatus are therefore inherently associated with the analyser. Moreover, elements, such as the acoustic meter, are specifically designed to perform both gas analysis and thermometer calibration functions to thereby reduce component costs.

According to a second aspect of the present invention there is provided a method of calibrating a resistance thermometer, by which method the apparatus according to the first aspect operates.

An exemplary embodiment of the present invention will now be described with the aid of the drawing of the accompanying figure:

Fig. 1 shows an apparatus and analyser according to the present invention.

Considering now the apparatus of Fig. 1., a measurement cell 2 is provided having an internal flow conduit 4 for the through flow of a gas composition the temperature of which is to be measured by means of a platinum wire resistance element 6. The measurement cell 2 may, as illustrated in the figure, be an integral part of a pneumatic circuit which is shown generally at 8 or may be a separate unit capable of gas connection to such a circuit 8.

The platinum wire resistance element 6 is located within the flow conduit 4 and is provided in electrical connection with a bridge circuit 10 of known construction. The element 6 and the bridge circuit 10 together form a known platinum resistance thermometer, the output of which is to be

calibrated using the apparatus according to the present invention.

Provided as an element of the apparatus is a reference thermometer 12, such as a known thermoelement or PT100 based measurement instrument, which in the present embodiment may be introduced into the internal flow conduit 4 through an externally accessible gas tight seal 14 within the measurement chamber and a complementary acoustic transmitter 16/receiver 18 arrangement which together with associated control and measurement electronics 20 form an acoustic meter of known construction. In the present example the acoustic transmitter/receiver arrangement 16,18 is shown as separate devices located directly facing one another across the measurement cell 2. It will be appreciated that other known configurations of separate transmitter 16 and receiver 18 devices as well as an acoustic transceiver element may be employed to delimit an acoustic path, 22 through gas within the cell 2 without departing from the invention as claimed. In the present embodiment a separate calibration unit 24 is also provided as an element of the apparatus. This unit 24 may be realised in a suitably programmed microcomputer having connected appropriate known interface devices for appropriately conditioning incoming and/or outgoing signals.

During a first phase of a calibration procedure the calibration unit 24 is adapted to receive a signal from the reference thermometer 12 as a first reference temperature value which is indicative of an equilibrium temperature of a gas composition within the flow conduit 4 of the measurement cell 2. Since the temperature measured is an equilibrium temperature then a reference thermometer 12 having a relatively long time constant may be used. The calibration unit 24 is also configured to receive during this first phase an output signal from the resistance thermometer 6,10 as a first temperature measurement value and to store, for example

in an associated digital memory, the two first values in a referenced fashion.

During a second phase of the calibration procedure which is carried out at a second, non-equilibrium, temperature of the gas composition the calibration unit 24 is adapted to receive from the acoustic meter 16,18,20 a signal related to an acoustic velocity within the gas composition. This signal may, for example, be an actual velocity value or a transit time value for acoustic energy emitted by the transmitter 16 to traverse the acoustic path 22 and be received by the receiver 18. The latter being provided particularly if the length, L, of the acoustic path 22 is unknown. The calibration unit 24 may, for example, be configured to provide a trigger signal to the control and measurement electronics 20 to initiate transmission of acoustic energy from the transmitter 16 and to start a timer which stops upon notification of a receipt of the transmitted energy by the receiver 18. Interrogation of such a timer will thus provide a measure of the transit time, t, as is well known in the art. As an alternative other known acoustic velocity measurement techniques may also be employed to provide the appropriate acoustic velocity related signal.

The speed of sound, V, in a gas composition may be described by the known equation:

$$V = K\sqrt{T} \qquad (1)$$

where K is a constant dependent of the composition of the gas;
T is the absolute temperature of the gas; and
V is the acoustic velocity within the gas and is given by:

$$V = L/t \qquad (2)$$

where t is the transit time for acoustic energy along the acoustic path 22.

Thus from equations (1) and (2) the temperature, T, of the gas may be described according to the equation:

$$T = C/t^2 \qquad (3)$$

where C is a constant based on the composition of the gas and on the length, L, of the acoustic path 22.

Where the path length L is known or can by provided as an input to the calibration unit 24 then this may be employed in the calibrations unit 24, together with a known or input gas composition constant K, to determine a second reference temperature value according to equation (3) and using the signal provided by the acoustic meter 16,18,20. During the second phase the calibration unit 24 is configured to also receive an output signal from the resistance thermometer 6,10 as a second temperature measurement value and to store the two second values also in a referenced fashion.

To increase the utility of the calibration apparatus an assumption can be made that one or both of the path length, L, and the gas composition (hence K) is unknown. The acoustic meter 16,18,20 is then adapted to perform a further acoustic velocity related measurement during the first phase and supply a related output signal to the calibration unit 24. The calibration unit 24 is then further adapted to utilise this signal, together with the first reference temperature value, to determine the unknown value or a ratio of the unknown values using equations (1) and (2). The so determined parameter may then be employed by the calibration unit 24 in the determination of the second reference temperature value since the gas composition remains unchanged between the two phases of the calibration procedure.

It is particularly advantageous if the acoustic velocity related measurement can be performed as quickly as possible after introduction of the gas composition at the second temperature into the measurement cell 2 since any errors which may be introduced due to a change in the length, L, of the acoustic path 22 caused by thermal expansion or contraction of the measurement cell 2 as the system equilibrates can be avoided.

The calibration unit 24 is further adapted to recall the first and second reference and measurement temperature values and to perform a two point calibration of the resistance thermometer 6,10 in a known manner, for example to perform a straight line fit of the calibration points, and thereby establish a calibration relationship between reference temperatures and measurement temperatures. During use of the resistance thermometer 6,10 its output can be translated into a temperature value, for example within the calibration unit 24 using the above mentioned established calibration relationship.

As described above, it is not necessary to have knowledge of the gas composition during the calibration procedure. However, it will be appreciated that an output from the resistance thermometer 6,10, calibrated using the above described apparatus and related method, may be employed together with a preferably simultaneous acoustic velocity related measurement signal output from the acoustic meter 16,18,20 to derive information about the composition of the gas within the measurement cell 2 using, in a known manner, the equations (1) (2) or (3) above. To this end the calibration unit 24 may be additionally programmed to perform such a derivation. Thus an accurate, relatively inexpensive, gas composition analyser 26 having an integral resistance thermometer calibration apparatus may be provided which employs the same components for the two devices.

The exemplary embodiment of the apparatus according to the present invention is configured to perform only a two point calibration of the resistance thermometer it will be appreciated that, without departing from the invention as claimed, any number of further calibration points may be provided by employing the acoustic meter 16,18,20 to generate the further reference temperature values in a manner substantially similar to that described with reference to the second phase of the calibration procedure.

Claims

1. A calibration apparatus for a resistance thermometer (6,10) comprising a reference thermometer (12) locatable in thermal contact with a gas composition to generate a first reference temperature value for the gas composition at a first temperature characterised in that there is also provided an acoustic meter (16,18,20) locatable in acoustic contact with the gas composition and adapted to make an acoustic velocity related measurement for use in generating a second reference temperature value for the gas composition at a second temperature.

2. An apparatus as claimed in Claim 1 characterised in that acoustic meter (16,18,20) is further adapted to perform an acoustic velocity related measurement for the gas composition at the first temperature for use also in generating the second reference temperature value.

3. A gas composition analyser (26) comprising a measurement cell (2); a resistance thermometer (6,10) thermally coupled to internal the cell (2); an acoustic meter (16,18,20) acoustically coupled to internal the cell (2) for monitoring a velocity of acoustic energy transmitted along an acoustic path (22) within the cell (2) characterised in that the analyser further comprises a reference thermometer (12) locatable in thermal coupling to internal the cell (2) and operable to generate during a calibration procedure a first reference temperature value for gas at a first temperature; in that the acoustic meter (16,18,20) is operable during the calibration procedure to provide an acoustic velocity related measurement in gas within the cell (2) at a second temperature for use in generating a second reference temperature value; and in that the analyser further comprises a calibration unit (24) adapted to determine a calibration relationship for the resistance thermometer (6,10) from the first and the second reference

temperature values and from measurement values of the first and the second temperatures supplied by the resistance thermometer (6,10).

4. An analyser as claimed in Claim 3 characterised in that acoustic meter (16,18,20) is further adapted to operate during the calibration procedure to provide a further acoustic velocity related measurement in the gas within the cell (2) at the first temperature and in that the calibration unit (24) is adapted to generate the second reference temperature value also using the further acoustic velocity related measurement.

5. A method of calibrating a resistance thermometer comprising the steps of:
obtaining into a calibration unit using a reference thermometer a first reference temperature value for a gas composition at a first temperature and a first measurement temperature value using the resistance thermometer;
obtaining into the calibration unit using an acoustic meter an acoustic velocity related measurement value for use in determining a second reference temperature value for a gas composition at a second temperature and a second measurement temperature value using the resistance thermometer; and
calculating within the calibration unit a relationship from the first and second reference temperature values and the first and second measurement temperature values for use in calibrating the resistance thermometer

6. A method as claimed in Claim 5 characterised in that there is provided an additional step of:
obtaining into the calculations unit using the acoustic meter an acoustic velocity related measurement at the first temperature for use in determining the second reference temperature value.

Abstract

Apparatus for and Method of Calibrating a Resistance Thermometer and a Gas Analyser Employing the Same

A calibration apparatus for a resistance thermometer (6,10) comprises a reference thermometer (12) locatable in thermal contact with a gas composition to generate during a calibration period a first reference temperature value for the gas composition at a first temperature and an acoustic meter (16,18,20) locatable in acoustic contact with the gas composition and adapted to make during the calibration period an acoustic velocity related measurement for use in generating a second reference temperature value for the gas composition at a second temperature. A calibration unit 24 is adapted to coordinate the first and second reference temperature values with first and second measurement temperature values provided by the resistance thermometer (6,10) at the first and the second temperatures respectively and to establish a calibration relationship therefrom.

Fig. 1

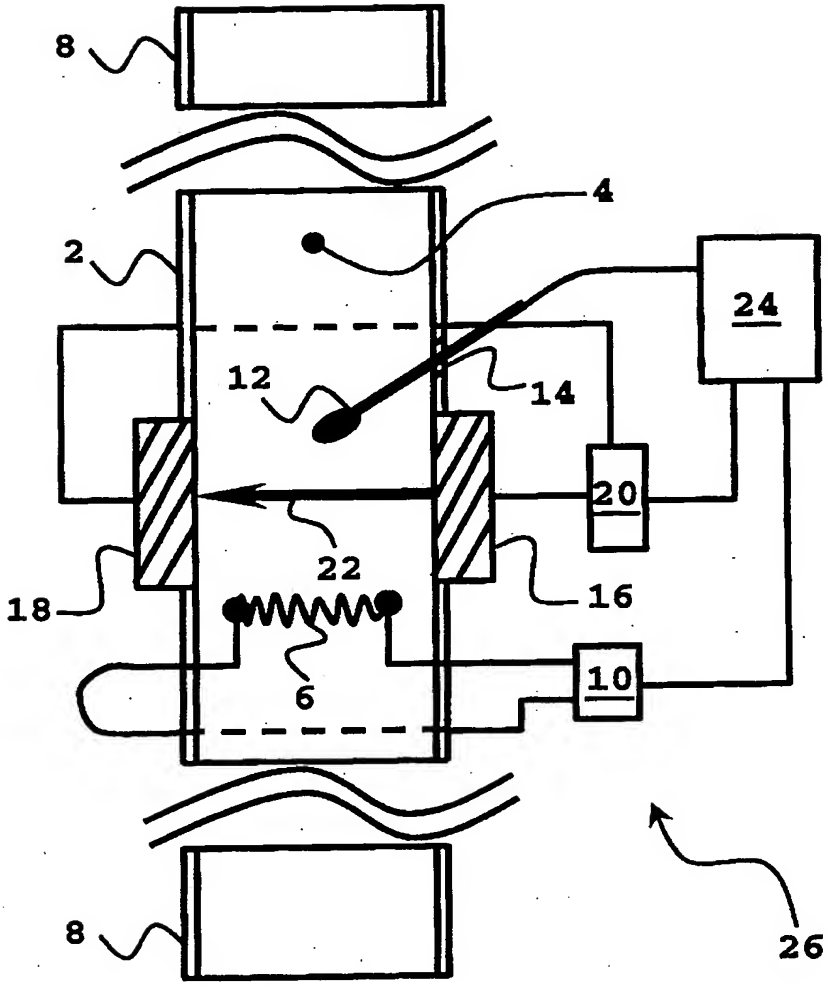

Fig. 1